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Hoff, D.J., et al., "A Biological Assessment of the Acushnet River Estuary." Unpublished report by University of Southeastern Massachusetts (1973).

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# A BIOLOGICAL ASSESSMENT OF THE ACUSHNET RIVER ESTUARY

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# HYDROGRAPHIC DESCRIPTION

Descriptions of hydrographic parameters of the estuarine system of New Bedford Harbor and the Acushnet River are few. Two recent quantitative studies contain some information of hydrographic value: Publication #6046 of the Massachusetts Water Resources Commission and an Environmental Impact Statement filed by the U. S. Army Corps of Engineers, New England Division, in September, 1972. From these studies and from data gathered by activities of members of the Biology Department of Southeastern Massachusetts University, certain generalizations about the hydrography of the area can be made:

1) The volume of flow from the Acushnet River into the tidal portion of the estuary is quite small relative to the tidal volume, hence tidal action is the most significant agent for dispersal of wastes.
2) Water movement upstream is extremely sluggish and is impeded by bridgeheads at Coggeshall Street and Pope's Island.
3) Flushing of the lower harbor area is extremely slow in the basin to the west of Palmer Island, but is good in the center channel area due to tidal currents.
4) Stratification occurs during summer months which leads to anoxic conditions on the bottom, especially in peripheral shoal waters.

In December, 1972, a dye study was performed in the river to estimate rates of water movement and dispersal of materials introduced upstream.

Dye (Rhodamine WT) was introduced by pumping into a streambed diffuser at the extreme northern extent of the tidal portion of the river. Dye was introduced for 24 hours, starting at approximately 0900 hours on December 5, 1972. Samples were taken twice daily at a variety of sampling locations downstream. The water samples were immediately removed to the laboratory and readings were taken after samples were brought to constant temperature in a water bath. Techniques used were essentially similar to those described in Book 3, Applications of Hydraulics, USGS.

Figures 1a-h depict the progress of the dye downstream and its dispersal throughout the lower harbor region. Two days elapsed before the leading edge of the dye mass reached the hurricane barrier. This indicates a surface water rate of flow (a maximum figure due to the fact that heavy rains preceded the measurements) of approximately 2 miles/day. This figure, however, is not indicative of the dispersal rate of dissolved substances. Figures 1a-h illustrate that appreciable dye concentrations are still evident in areas in the lower harbor on December 8, even though the concentrations observed at the entrance to the hurricane barrier have fallen to undetectable levels by the end of that day (Figure 2). In other words, materials are rapidly flushed out of the harbor channel relative to the shoaler shoreline water.

A notable feature of the distribution of the dye mass in the river was the tendency of the dye to concentrate on the westerly bank. This may be due to the predominance of freshwater input from outfalls on the easterly bank (Water Quality Study, 1972), which would cause dilution of materials on that side. Coriolis deflection may also account for higher concentrations to the right of the net direction of trawl. Preliminary generalizations regarding patterns of water circulation and exchange that seem justified by the results of this study are:

1) Materials added to the estuary at points above the Pope's Island bridge may tend to concentrate in certain areas downstream, and are

<u>Figure 1c</u>. December 6, 0900 Ebb Tide

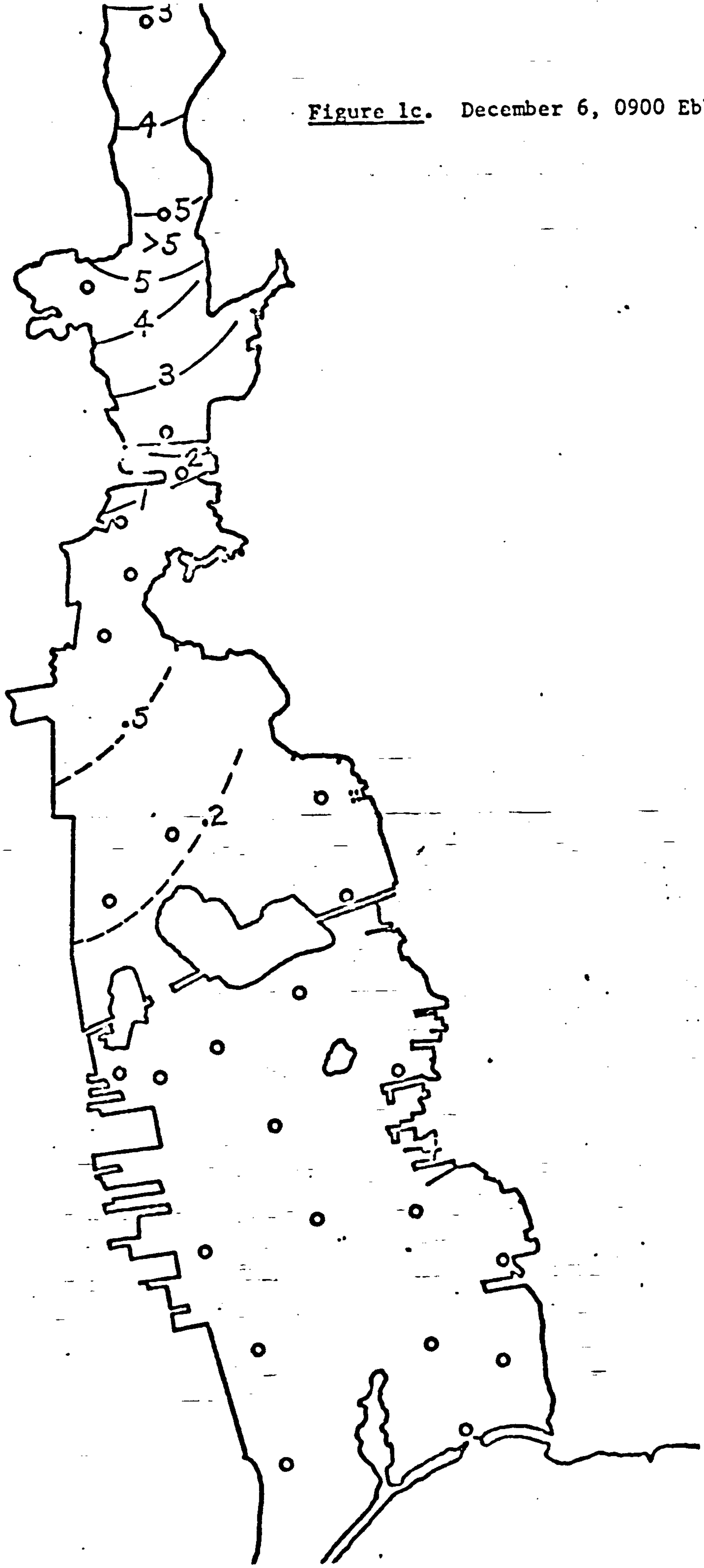


Figure 1d. December 6, 1100 Flood Tide

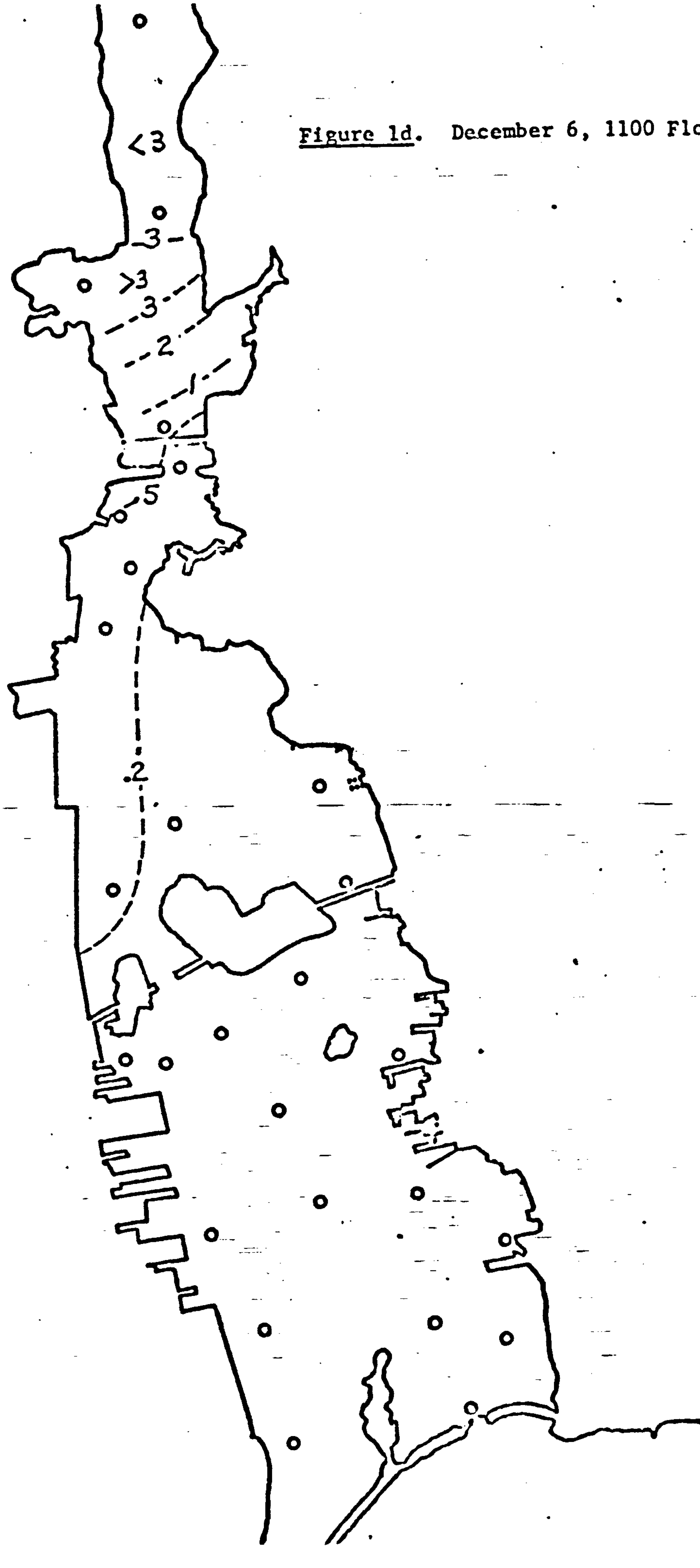


Figure 1e. December 6, 1500 Flood Tide

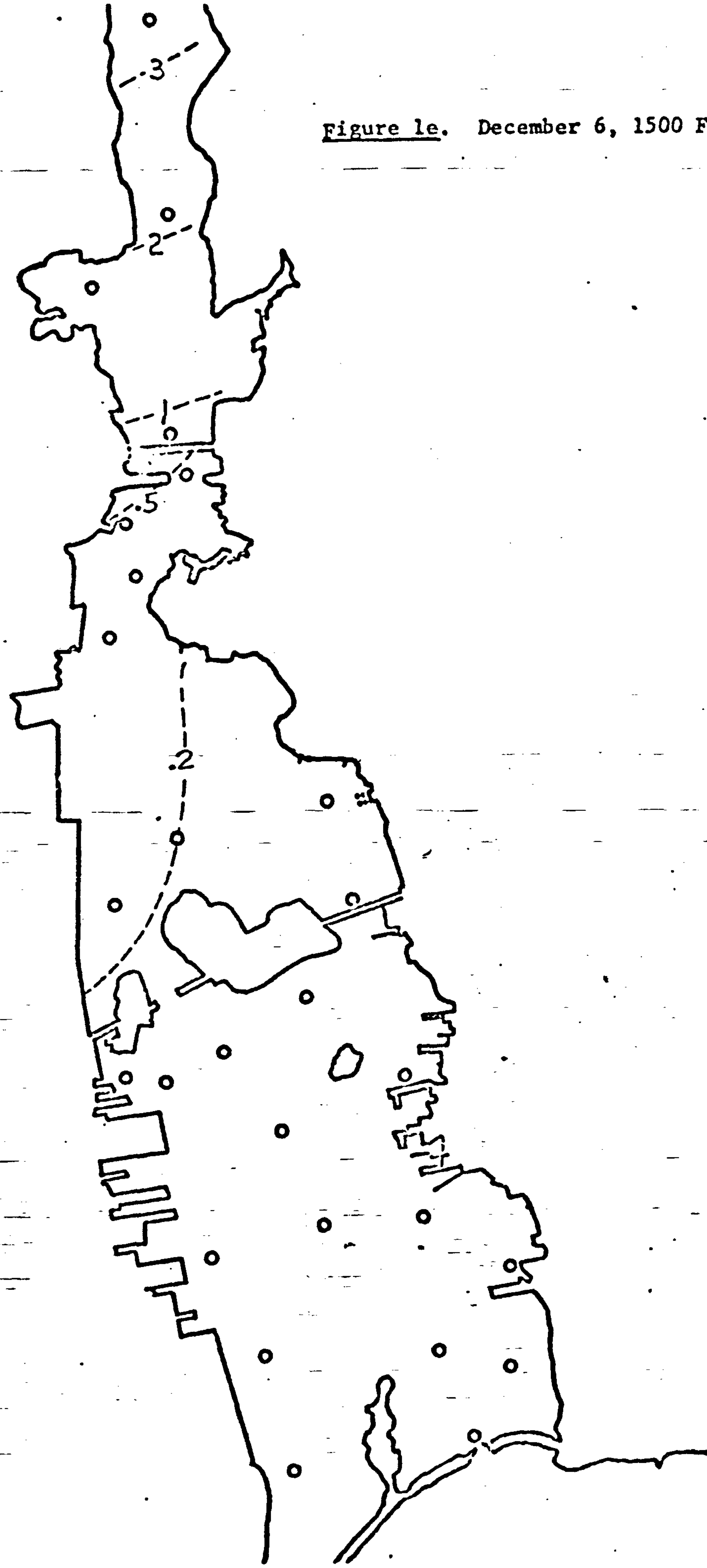
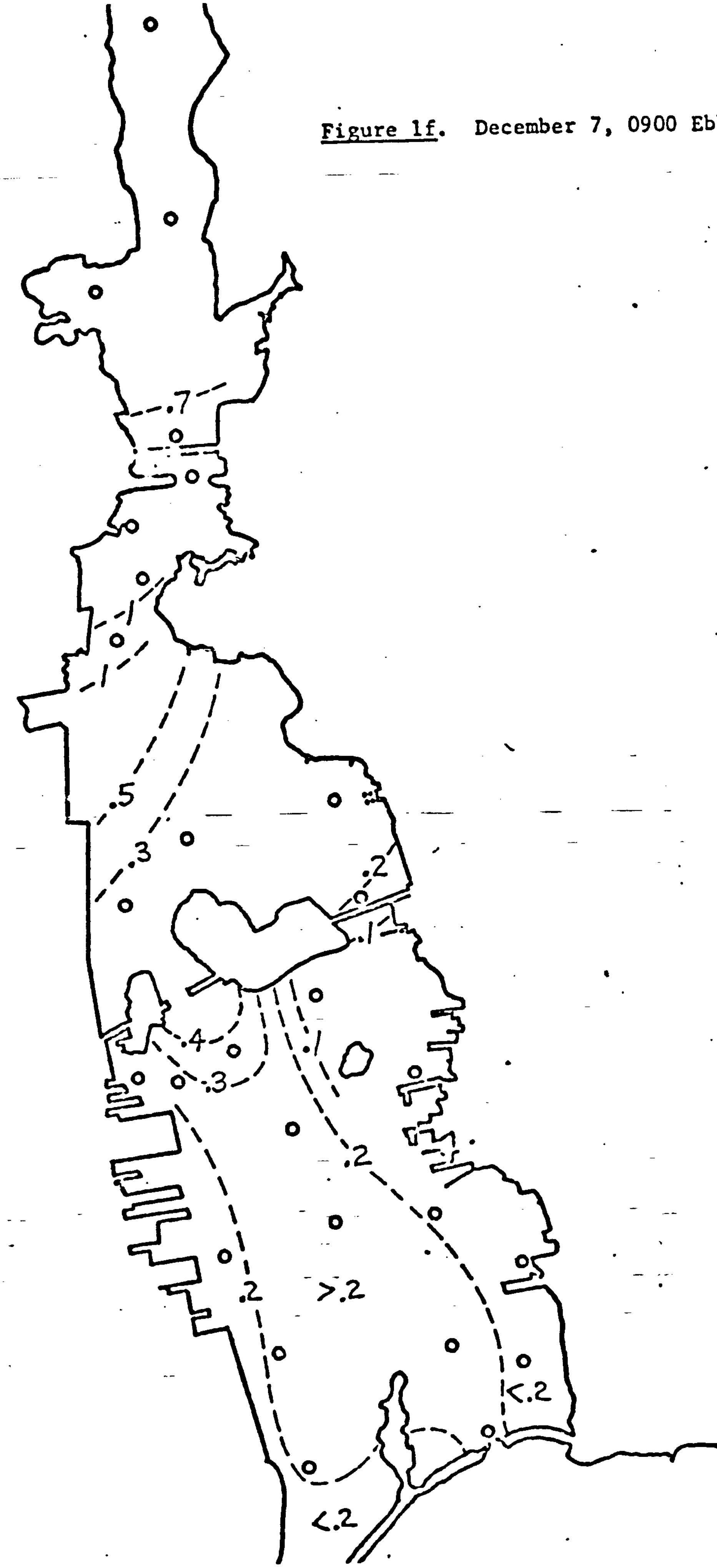


Figure 1f. December 7, 0900 Ebb Tide



## BENTHIC INVERTEBRATE FAUNA

A survey of the benthic invertebrate fauna was conducted in December, 1972, in the Acushnet River between the Fairhaven Bridge and the Hurricane Dike. Twenty-seven species of epifaunal invertebrates were collected from three hauls made with a one-half size commercial otter trawl. These species are listed in figure 1. They represent a diverse assemblage of animals which compare favorably with the epifaunal invertebrate community found inhabiting nearby estuaries and embayments. The majority of these species are non-migratory and therefore constitute a continuous resident population in this section of the Acushnet River. Approximately ten species are motile and may migrate from this region during different seasons of the year. Other species of epifaunal invertebrates are undoubtably found inhabiting this section of the river but their motility or their small size enabled them to avoid capture in the trawl.

Infaunal invertebrates are noticably absent from this region of the Acushnet River. Bottom samples were taken at nine locations with a one-tenth square meter vanVeem bottom grab and examined for invertebrates which live in, or borrow into, the sediments. No macroscopic infaunal species were found. An analysis of the sediments collected at these locations showed a relatively high percentage of silts and clays, as well as, a high degree of saturation with petroleum residues. This combination of factors precludes successful recruitment and survival of most infaunal species.

Observation made during trawls in the spring and summer of 1973 reveal that a diverse and abundant invertebrate fauna is maintained throughout the year in the river and there is no evidence that I have seen to suggest that the invertebrate community is adversely affected by thermal additions to the river.

This study did not reveal statistically significant differences in the density of fish eggs and larvae inside, outside, or between the Acushnet and Westport River estuaries. Either no differences exist or the data obtained are inadequate to demonstrate a difference.

TABLE 1. LIST OF INVERTEBRATE SPECIES COLLECTED FROM THE ACUSHNET RIVER IN DECEMBER, 1972.

| SPECIES NAME | COMMON NAME | NUMBER |
|---|---|---|
| Aequipecten irradians | bay scallop | 17 |
| Anadara ovalis | blood ark | 1 |
| Anadara transversa | transverse ark | 1 |
| Anomia simplex | jingle shell | 3 |
| Asterias forbesi | common starfish | 7 |
| Balanus amphitrite niveus | barnacle | TNC* |
| Busycon caniculatum | channeled whelk | 4 |
| Callinectes sapidus | blue-claw crab | 64 |
| Cancer irroratus | rock crab | 5 |
| Crangon septemspinosus | sand shrimp | 15 |
| Crepidula convexa | slipper limpet | 7 |
| Crepidula fornicata | slipper limpet | TNC* |
| Crepidula plana | slipper limpet | TNC* |
| Filograna implexa | serpulid tube worm | TNC* |
| Homarus americanus | american lobster | 2 |
| Hydroides dianthus | serpulid tube worm | TNC* |
| Libinia emarginata | spider crab | 7 |
| Metridium dianthus | sea anemone | 1 |
| Modiolus demissus | ribbed mussel | 1 |
| Neopanope texana | mud crab | 110 |
| Ovalipes ocellatus | lady crab | 6 |
| Pagurus longicarpus | hermit crab | 3 |
| Paleomonetes vulgaris | prawn | 7 |

* too numerous to count

TABLE 1. CONTINUED

| SPECIES NAME | COMMON NAME | NUMBER |
|---|---|---|
| *Spirobis spirillum* | serpulid tube worm | TNC* |
| *Squilla empusa* | mantis shrimp | 9 |
| *Toredo navalis* | shipworm | TNC* ** |
| *Zirfaea crispata* | boring piddock | 11 ** |

* too numerous to count

** in submerged wood piling

## FINFISH FROM THE ACUSHNET RIVER

Trawl samples in December 1972, April 1973 and December 1973 have shown the presence of nine species of fish in the Acushnet River. These samples were taken from the lower section of the river between the hurricane barrier and Pope Island.

In December 1972 a comparable trawl sample was taken outside the hurricane barrier. It is interesting to note the inside fish fauna on this date was quantitatively and qualitatively richer.

Included in these Acushnet River fish are the commercially important striped bass, white perch, winter flounder, alewife, smelt and menhaden.

In addition to the species collected by trawling, I have seined Menidia menidia, Atlantic silverside, Fundulus heteroclitus, mummichog, and Fundulus majalis, striped killifish, from the river, and it is well known that in the summer of 1973 a population of Pomatomus saltatrix, bluefish, gave New Bedford anglers many fishing thrills in the lower reaches of the river.

FISH SPECIES COLLECTED BY TRAWL FROM THE
ACUSHNET RIVER, NEW BEDFORD, MASS.

| Date | Species | No. of Individuals |
|---|---|---|
| Dec. 1972 | *Scopthalmus aquosa*, windowpane flounder | 103 |
| | *Pseudopleuronectes americanus*, winter flounder | 77 |
| | *Gobiosoma ginsburgi*, goby | 21 |
| | *Tautogolabrus adspersus*, cunner | 8 |
| | *Alosa pseudoharengus*, alewife | 4 |
| | *Morone saxatilis*, striped bass | 3 |
| | *Osmerus mordax*, smelt | 1 |
| | *Brevoortia tyrannus*, menhaden | 1 |
| April 1973 | *Pseudopleuronectes americanus*, winter flounder | 42 |
| | *Scopthalmus aquosa*, windowpane flounder | 17 |
| | *Tautogolabrus adspersus*, cunner | 9 |
| | *Alosa pseudoharengus*, alewife | 19 |
| | *Gobiosoma ginsburgi*, goby | 11 |
| | *Morone americanus*, white perch | 6 |
| Dec. 1973 | *Scopthalmus aquosa*, windowpane flounder | 40 |
| | *Pseudopleuronectes americanus*, winter flounder | 71 |
| | *Gobiosoma ginsburgi*, goby | 27 |
| | *Tautogolabrus adspersus*, cunner | 11 |

## FISH SPECIES COLLECTED OUTSIDE HURRICANE BARRIER

| Date | Species | No. of Individuals |
|---|---|---|
| Dec. 1972 | Scopthalmus aquosa, windowpane flounder | 41 |
| | Pseudopleuronectes americanus, winter flounder | 19 |
| | Tautogolabrus adspersus, cunner | 3 |
| | Morone saxatilis, striped bass | 2 |
| | Osmerus mordax, smelt | 1 |
| | Menidia menidia, Atlantic silverside | 1 |

## PLANKTON

During student exercises, the presence of abundant microcrustacean zooplanktus have been observed from net tows taken from the Pope's Island Bridge. Phytoplankton production has been documented in the estuary as well (see reference 1 in Literature Cited section).

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1. Publication #6046, Massachusetts Water Resources Commission, "Acushnet River-New Bedford Harbor Water Quality Study 1971", January, 1972.
2. Final Environmental Impact Statement, U. S. Army Corps of Engineers, New England Division, "Operation and Maintenance of New Bedford Hurricane Barrier", September, 1972.
3. Chapter A12, Book 3, Applications of Hydraulics, "Techniques of Water Resources Investigations of the USGS - Fluorometric procedures for Dye-Tracing", James F. Wilson, Jr., 1968.

# APPENDIX

Literature Articles Relevant to the Biological Condition of New Bedford Harbor.

Table 4. Concentration of nitrates.

| Location | Date | ug at/l* NO₂-N | |
|---|---|---|---|
| | | $NO_2$ - N | $NO_3$ - N |
| Station 1 | 2-16-70 | 0.12 | < 30 |
| | 3- 4-70 | 0.20 | < 30 |
| Station 2 | 2-16-70 | 0.43 | 7.17 |
| | 3- 4-70 | 1.48 | 26.52 |
| Station 3 | 2-16-70 | 0.44 | 7.66 |
| | 3- 4-70 | 0.18 | 2.52 |
| Station 4 | 2-16-70 | 0.10 | 2.40 |
| | 3- 4-70 | 0.07 | 1.33 |

* Microgram atoms per liter.

Table 5. Concentration of phosphates.

| Location | Date | Inorganic-P ug at/l* |
|---|---|---|
| Station 1 | 2-16-70 | .940 |
| | 3-18-70 | .254 |
| | 5- 4-70 | .244 |
| Station 2 | 2-16-70 | 1.52 |
| | 3-18-70 | 9.40 |
| | 5- 4-70 | 5.08 |
| Station 3 | 2-16-70 | 2.67 |
| | 3-18-70 | 2.30 |
| | 5- 4-70 | 1.07 |
| Station 4 | 2-16-70 | .583 |
| | 3-18-70 | .343 |
| | 5- 4-70 | .418 |

*The New Bedford sewer system was constructed in 1852. Since 1917 an interconnecting sewer line has been in operation which is supposed to funnel all the raw sewage beyond station 4. However, direct outfalls do occur along the river.*

The BOD values in the Acushnet River are extremely high (Table 3). In fact, some of the upriver values are comparable to raw sewage influent concentrations. At Station 2, dilutions of 2 percent were used to obtain valid readings. This dilution alone classifies this water as raw unsettled sewage. At Station 3, the sample dilutions were from 25 to 50 percent, which is comparable to sewer plant effluents of primary treatment (screening) only. No other parameter in the study was more significant to the class. Here, the terms self-purification, eutrophication, and sewage overloads had meaning.

## Inorganic Nutrients

Many techniques are available for the determination of nitrates and phosphates in water. One technique employs a portable kit which is ideal for the high school where time and funds are limited. In this study phosphate-phosphorus was analyzed according to the ascorbic acid, single solution method; and nitrate-nitrogen, by the cadmium amalgam method.

Limiting values as well as pollution levels for inorganic phosphorus and nitrate concentrations in aquatic ecosystems are widely covered in the literature. The immediate salient feature of the inorganic nutrients is the extremely high values in the mid river section (Tables 4 and 5). These values are from five to ten times those found in adjacent waters of Buzzards Bay. The values compare to the highly polluted Hutchinson River area in New York and seem to be the expected values in the more and more commonly occurring eutrophicated Northeast Coast estuaries.

## In Retrospect

Traditionally we have never understood or even been interested in the ecological effects until after they are produced. Basically the situation is this simple: Our ability to pollute and disrupt has far outdistanced our ability to understand what we are doing.

Man is experiencing environmental deterioration daily because natural environmental systems are not able to absorb or recycle the increasing waste products produced almost indiscriminately by human populations. The side effects of Western civilization's technology have been rather large-scale interruption and destruction of environmental systems, the very systems upon which we, and all living things, depend. The realization that we must face is that to continue such conflict with environmental systems will force us to compromise even more drastically between our standard of living and our survival. We are at the beginning of a new phase of man's history when he must face ecological realities. He must begin in his own backyard.

Assuming that man successfully stabilizes his population, what are the keys to the success of solving environmental problems? First, the educational system must recognize the essence of the problem. All aspects of pollution must be defined and studied within the school curricula. Only in this way will a national sense of awareness evolve. Foolish activities, such as burying the internal combustion engine, and the confusion of beautification with environmental conservation not only indicate a failure of the educational system but are themselves often a waste of human energy. Studies such as the one reported here are far more meaningful and useful. Second, a land ethic as proposed by Aldo Leopold must be central to all educational experiences. Evidence of the lack of a land ethic are omnipresent. The land-water relation is still strictly economic, entailing privileges but no obligations. The employment of a river as a sewage treatment facility by an entire municipality clearly demonstrates the need for a land ethic. □

ACKNOWLEDGMENTS:

Thanks are extended to Chuck Townsend for the photograph, Ann Harrington for the tables, and to all participants in the seminar in water pollution.

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of bacteria has been used to indicate the pollution of waters. Full discussions can be found in most texts on bacteriology. Experience has established the significance of coliform group densities as criteria of the degree of pollution.

The membrane filter technique, which provides a direct plating for the detection and estimation of coliform densities was employed in this study.

The Division of Water Pollution Control of the Commonwealth of Massachusetts has established water quality standards for marine and coastal waters. The lowest acceptable class (SB) for bathing and recreational purposes is defined as "the acceptable coliform counts not to exceed a median value of 700 and not more than 2300 in more than 10% of the samples in any monthly sampling period." Stations 1, 2, and 3 are clearly grossly polluted and do not meet the class (SB) requirement (Table 2). The New Bedford beaches are near station 4. The data are not sufficient to accept or reject this area as class (SB). However, the data indicate that continuous monitoring is necessary if public health problems are to be avoided. With such a massive source of contamination near a recreational area, coupled with higher summer water temperatures, the proper set of conditions might give rise to drastic elevations in coliform count.

## Benthic Invertebrates and Sediments

Each of the four stations varied ecologically as to the progressive differences normally established for an estuarine river system from the fresh-water head region to the euhaline mouth. The invertebrate faunal sampling was done on a random qualitative basis in association with sediment and salinity sampling.

The purpose was to look for biological indicators or organisms that would reflect an index of water pollution. Biological indicators include the presence of certain plants and animals which experience has shown to be significantly characteristic of kinds and degrees of pollution; they may also refer to the absence of organisms known to be highly intolerant of polluted conditions.

Station 1 was characterized by numerous fresh-water pollution indicator organisms. To name a few: *Sphaerotilus*, sewage fungus; *Tubifex*, sludgeworm; *Chironomus*, blood worm; and *Asellus*, sow bug. Sediment samples from Station 2 are characteristically layered with one to two inches of oil over an inch of silt. The number of individual organisms as well as species collected here is very small, and the evidence of pollutional restrictions is overwhelmingly evident. Over 98 percent of the samples contained no living macrobenthic organisms. Station 3 shows increasing species variation, with a small number of more tolerant polyhaline species as the dominant members of the benthic organisms, and a correlated factor of species absence with proportional intolerance. Station 4 demonstrates the more indirect effects of organic pollution, by accentuating the "indicator by absence" principle and relating the limiting effects of marine pollutional changes to a larger community.

## Biochemical Oxygen Demand

Biochemical Oxygen Demand is the measurement of the oxygen utilized in the stabilization of the organic matter in sewage by microorganisms over a five-day period at 20°C. The rate of oxygen depletion depends on the amount of oxidizable organic matter and the number of microorganisms. This rate will determine the BOD value of the water sample. There are numerous problems that arise in determining the BOD. A few are: (a) photosynthesis by algae, (b) acclimation of bacteria, (c) sample dilution, and (d) toxic substances. The understanding and the controlling of these parameters give the student an opportunity to encounter problems that are fundamental to population ecology.

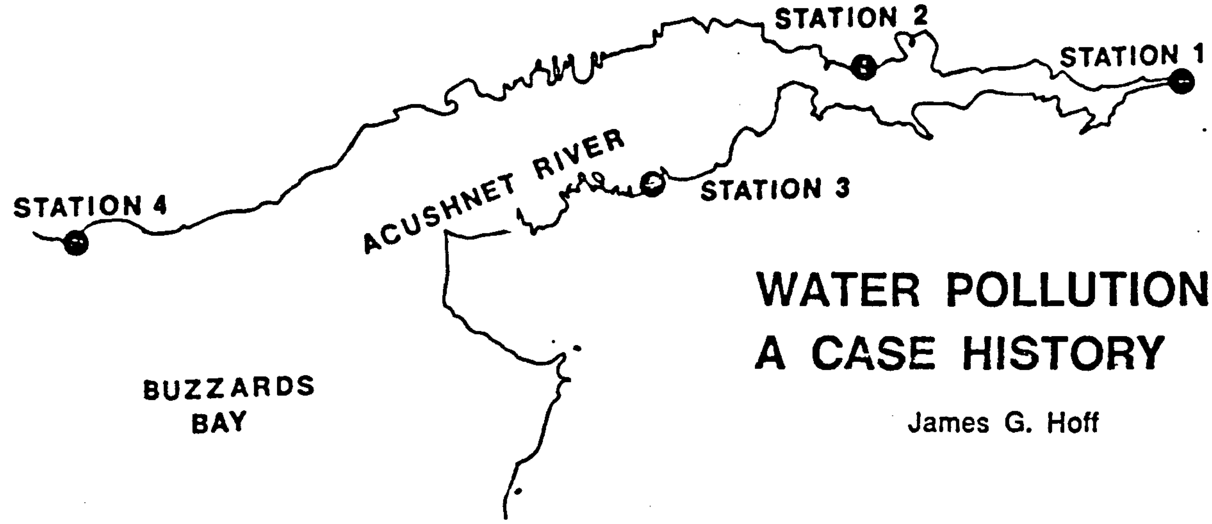
BOD bottles were used for the collection of samples, and the dissolved oxygen was determined by the sodium azide modification of the Winkler method.

Table 2. Coliform and Streptococcus concentrations in the Acushnet River.

| | Numbers of viable cells per 100 ml | | |
|---|---|---|---|
| Location | Date | Coliform | Strep |
| Station 1 | 2-19-70 | 120,000 | 200 |
| | 3- 4-70 | 170,000 | 400 |
| | 3-20-70 | 22,000 | 400 |
| | 5-16-70 | 120,000 | 200 |
| Station 2 | 2-19-70 | 13,000 | 4,900 |
| | 3- 4-70 | 550,000 | 90,000 |
| | 3-20-70 | 380,000 | 14,000 |
| | 5-16-70 | 120,000 | 800 |
| Station 3 | 2-19-70 | 4,600 | 200 |
| | 3- 4-70 | 600 | 65 |
| | 3-20-70 | 2,000 | 400 |
| | 5-16-70 | 1,600 | 200 |
| Station 4 | 2-19-70 | 700 | 65 |
| | 3- 4-70 | 15 | 5 |
| | 3-20-70 | 170 | 25 |
| | 5-16-70 | 200 | 25 |

Table 3. Biological oxygen demand values in the Acushnet River. Station 2 values are comparable to sewer influents.

| Location | Date | BOD—ppm |
|---|---|---|
| Station 1 | 3-20-70 | 2.96 |
| | 4-16-70 | 2.25 |
| | 4-21-70 | 2.14 |
| | 5- 7-70 | 2.50 |
| Station 2 | 3-20-70 | 27.35 |
| | 4-16-70 | 70.50 |
| | 4-21-70 | 95.50 |
| | 5- 7-70 | 95.70 |
| Station 3 | 3-20-70 | 5.50 |
| | 4-16-70 | 11.10 |
| | 4-21-70 | 10.90 |
| | 5- 7-70 | 10.70 |
| Station 4 | 3-20-70 | 8.66 |
| | 4-16-70 | 11.75 |
| | 4-21-70 | 11.60 |
| | 5- 7-70 | 10.90 |




# WATER POLLUTION—A CASE HISTORY

James G. Hoff

THIS is a study of domestic water pollution, undertaken to further environmental understanding. The students were college biology majors, though high school students in several science courses could also make such a study. The scope of the study might change, some accuracy might have to be sacrificed, but the principles and relevancy of the material would remain. Since everyone contributes to the domestic waste problem, all students find themselves polluters. In this study we were concerned with parameters that indicate sewage pollution.

The distinguishing feature of this learning experience is that it concerned contemporary problems. It involved hard work and indicated that the way to discovery is challenging and difficult and requires cooperation and self-sacrifice. The problem is still unresolved, but it is now better understood. Most important, a valuable source of information was identified and is available for the entire community.

## Area Description

The Acushnet River is tidal, approximately five miles in length, and flows between New Bedford to the west and Fairhaven and Acushnet to the east, eventually terminating in Buzzards Bay, Massachusetts. It is home port to one of the East Coast's largest ground fishing and scallop fleets. It has heavy and light industries on its banks. It is beset with varied domestic and industrial pollution problems. The untreated wastes of approximately 200,000 people enter the watershed daily.

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## Total Microbes

Estimates on the total microbial population were among the first tests to be applied to water bodies in order to determine the nature and extent of their pollution. Total microbial counts have been essentially ignored as diagnostic methods for the past three decades in favor of coliforms. While the preoccupation with human sewage as a polluting agent is largely justified, the total microbial count still has merit as a measurement of total organic matter in water systems. Microbial count is of value where the concern is with eutrophication rather than with disease transmission.

Table 1. Total microbe count and dates collections were made.

| Location | Date | Total Microbe |
|---|---|---|
| Station 1 | 3-20-70 | 1.8 |
| | 4-19-70 | 2.2 |
| | 4-30-70 | 2.3 |
| | 5- 7-70 | 2.1 |
| Station 2 | 3-20-70 | 2.4 |
| | 4-19-70 | 3.7 |
| | 4-30-70 | 4.1 |
| | 5- 7-70 | 1.6 |
| Station 3 | 3-20-70 | 0.1 |
| | 4-19-70 | 1.8 |
| | 4-30-70 | 1.2 |
| | 5- 7-70 | 1.2 |
| Station 4 | 3-20-70 | 0.1 |
| | 4-19-70 | 0.5 |
| | 4-30-70 | 0.7 |
| | 5- 7-70 | 0.8 |

Various media exist for the rearing of the total microbial fauna. In this study the agar used was the Plate Count Agar (Tryptone Glucose Yeast Agar). Plastic disposable petri dishes make ideal environments. The cultures are diluted, adjusted to a pH of 7, and incubated at 35° C for 24 hours. In the counting process, only plates showing between 30 and 300 colonies were considered, and all plates which fell within this range were averaged into the final count for each sample.

Total, microbial accounts above 1 million are indicative of polluted inshore waters. The data obtained in the study, in general, clearly indicated organic pollution. But more important, they indicated that the major sources from which organic wastes were entering the river in the upstream section were near stations 1 and 2. (See Figure 1 and Table 1.)

## Coliforms

The isolation of pathogenic bacteria or any microorganism from water is not recommended as a routine practice inasmuch as the techniques available are tedious and complicated. The results are not of major significance and may be confusing in a particular study of pollution.

For many years the coliform group

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# The Use of the Dilution Water Effect as a Water Quality Criterion

by

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A principal difficulty in the toxicology of marine organisms has been obtaining dilution water that is free from substances which may affect the response of a test organism to a toxin (WALDICHUK, 1973). Dilution water must be free of substances that place an additional stress on an organism which may in turn enhance its response to the toxic substance being tested. In other words, the dilution water must be "neutral" with respect to the toxin's effect.

The possibility of synergism between unknown chemical constituents in the dilution water and controlled additions of a toxin suggests and entirely different approach to assessing water quality. The dose-response relationship for a particular toxin or pollutant could be compared using relatively clean water as a control dilution water source and water suspected of being polluted as the test dilution water source. Thus what appears to be a technical problem in the generation of dose-response data may become a relatively simple means of assessing the potential of a marine body of water to receive additional amounts of a pollutant before toxic thresholds are reached.

A simple experiment was devised to illustrate the use of this technique. Brine shrimp nauplii are known to be an effective and convenient bioassay organism in seawater (TARPLEY, 1958). Freshly hatched nauplii were used as test organisms. Dilution water was taken from the Acushnet River estuary (harbor of New Bedford, Massachusetts) and from the relatively unpolluted of adjacent Buzzards Bay. Salinity, temperature, and dissolved oxygen content of the water sources were almost identical. Before use in the experiment, the water was filtered through membrane filters (0.45$\mu$ pore size) and allowed to stand to recover oxygen lost by the degassing which occurs during vacuum filtration. Methyl mecuric chloride was chosen as the test toxin and concentrations were made up ranging from 100 parts per $10^9$ to 1000 parts per $10^9$ in increments of 100 parts per $10^9$. Replicate determinations of brine shrimp mortality after 4 hours exposure were made for each concentration for each dilution water source. Test vessels were 125 ml flasks with 10-15 brine shrimp in 100 ml of medium. Concentrated methyl mecuric chloride stock was made up using artificial seawater.



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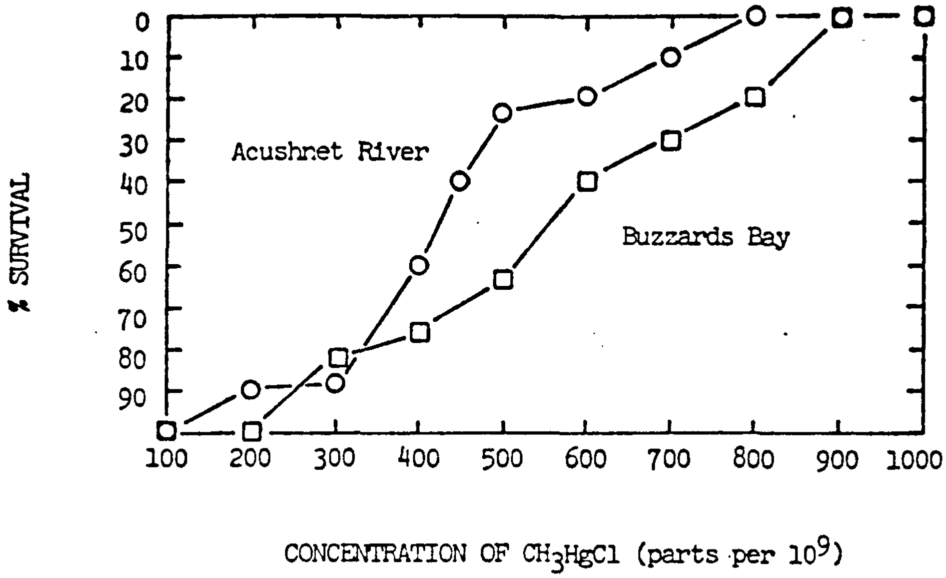


Figure 1. Effect of dilution water on the methyl mercuric chloride dose-response relationship of nauplii of *Artemia salina*. One intermediate dose was tested using the Acushnet River dilution water. Points shown are means of replicate determinations.

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